Reviews

LAYBOURN-PARRY J, TRANTER M and HODSON AJ (2012) *The ecology of snow and ice environments*. Oxford University Press, Oxford. 179pp. ISBN: 978-0-199-58307-2, hardback, £65; ISBN: 978-0-199-58308-9, paperback, £32.50.

It is only in the last two decades or so that snow and glacial environments have become the increased focus of ecological research. Before that, research on the cryosphere was mainly the domain of physical and chemical glaciological investigations, as the authors of *The ecology of snow and ice environments* point out. However, it has recently become evident that biological processes in the various frozen habitats, including sea ice and lake ice, snow, glaciers and ice sheets, may play an important role in the geochemical cycles of the cryosphere. Climate change, amplified in polar areas and also strongly affecting ice environments at lower latitudes, is significantly impacting on the cryosphere and has sparked additional interest. For example, the loss of Arctic sea-ice extent and its consequences for marine ecosystem function, in the past a topic for a few specialists, is now heavily discussed by the general public. This book, providing a summary overview of a variety of ice environments, their habitability and biological communities, and aimed at both non-specialists and specialists, is therefore a timely contribution to the field.

The book is ordered into seven chapters. Chapter 1 provides an introduction to multidisciplinary glaciological research. It introduces the reader to the basic principles of microbial ecology, glaciological chemistry and ice physics, covering a suite of cryospheric environments including lake and sea ice, glacial ecosystems and snow, but excluding permafrost. Biologically inclined readers will find this chapter particularly informative as it is gives a very good introduction to the physical processes and properties of snow, glacial as well as sea ice and lake ice. Geophysicists and physical glaciologists, however, may have difficulty understanding some of the biological and biogeochemical concepts, as descriptions of these are rather detailed. Nevertheless, this chapter provides a useful interdisciplinary knowledge base, and non-specialists should read it before attempting the more specific chapters.

Chapter 2, on snow, summarizes the results of various studies carried out in both polar and temperate regions. It highlights the role snow plays as habitat for microbial life, reservoir for nutrients and as insulating cover for soil and vegetation. The book's coverage of snow algae is rather brief. Most parts of this chapter are very specific and, in my opinion, too detailed for the non-specialist reader.

Chapter 3 covers ice surface environments and provides a comprehensive overview of the surface habitats on ice shelves, ice sheets and glaciers. It includes an excellent introduction to cryoconite biology, explaining cryoconite formation, environmental conditions and biogeochemical processes.

Sea ice, the area of my own expertise, is discussed in chapter 4. This chapter gives a good overview of polar sea-ice habitats and communities. However, the authors have focused only on a subset of the information and knowledge available to date. Some critically important concepts of physical forcing of sea-ice primary productivity, namely seasonal changes in sea-ice brine volume affecting permeability and percolation thresholds and controlling nutrient availability of sea-ice internal and surface communities, have been omitted. In addition, findings derived from individual regional studies have been extrapolated to the vast expanse of polar ice covers, while there is now a strong body of scientific literature highlighting regional and sectoral differences in sea-ice properties in both the Arctic and Antarctic. Despite these shortfalls, the chapter provides a good general introduction to sea ice and lake ice.

Chapter 5 addresses subglacial environments, and its coverage of this relatively new subject is very informative. Complex linkages of physical, biogeochemical and ecological processes both in and below glaciers are explained exceptionally well. Results from various sub-ice environments (e.g. subglacial drainage systems, subglacial lakes and permanently frozen lakes) are presented and synthesized.

Chapter 6, on astrobiology, highlights the strengths and weaknesses of using Earth's cryospheric environments as analogues for extraterrestrial environments. It also gives an overview of the potential past and present occurrence of liquid water in extraterrestrial subglacial environments on Mars, the Jovian moon Europa and the Saturnian moons Enceladus and Titan. This is an interesting chapter, but there is a lack of information on the phase behaviour of ice and the equilibrium structure of polycrystalline ice. A short introduction to the physics of surface melting, interfacial melting and grain boundary melting would have been useful for understanding the processes that form liquid water, the prerequisite for life in ice environments.

The concluding chapter describes future directions in cryospheric ecological research and highlights the need for integrated and truly multidisciplinary work. The authors give a very good overview of technical developments including the increasing use of autonomous underwater and unmanned aerial vehicles, spaceborne remote sensing and molecular techniques as well as the need for ecological modelling studies. As outlined by the authors, merging these various approaches is paramount for understanding cryospheric biological processes on ecologically relevant scales. A short glossary at the end provides non-experts with useful definitions of the many technical terms used in the book.

This book gives a good overview of glaciology, glacial geomicrobiology and biogeochemistry, as well as microbial ecology and astrobiology. By covering all these disciplines, such a compact volume (179 pages) falls somewhat short of providing an in-depth introduction to each of the specific topics. If a reader wants to gain specific knowledge of one of these disciplines or of a specific cryospheric habitat, other more specialized publications may be of more interest, a recommendation that is also made by the authors. My pleasure in reading the book was also marred by a slight overuse of biological jargon, as well as a number of typographical and contextual errors that could easily have been avoided. Some chapters lack integration of research results and read more like a summary listing of current knowledge. This may be considered typical of a new and fast-moving discipline; more studies are needed before integrated hypotheses on the structure and function of the various cryospheric communities can be formulated.

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Despite these weaknesses, the book provides a good summary of currently available information on cryospheric ecology and is generally well structured and written. Anyone wishing to gain a quick overview of recent advances in cryospheric ecological research will find it useful.

K.M. MEINERS
Australian Antarctic Division and
Antarctic Climate and Ecosystems CRC
University of Tasmania
Hobart, Tasmania, Australia
E-mail: klaus.meiners@aad.gov.au

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